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SEMI-ANNUAL REPORT ON NASA RESEARCH

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SEMI-ANNUAL REPORT ON NASA RESEARCH GRANT Nsg 249-62

Submitted by

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April 1, 1963

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I. Work Program

NASA Research Grant NsG 249-62 to the University of California at Los Angeles provided for the establishment of a space physics laboratory within the Institute of Geophysics and Planetary Physics. The purpose of this laboratory was to conceive and design experiments for space research, and to develop the instrumentation necessary to carry them out. These activities were to be carried out with the participation of graduate students of the University in order that scientific goals might be combined with the education of young scientists.

After this grant was received by the University, NASA made available an opportunity for the investigators under this grant to participate in a flight experiment on the Ranger 7, 8, and 9 space vehicles. The experiment consisted of an electron-proton spectrometer for charged particle measurements between the earth and the moon on the three Ranger flights. The development of the sensor configuration and the electronic circuits for this instrument were supported with grant funds, and the work was done in the newly created laboratory. Support for the construction of prototype and flight models was separately provided under a contract from Jet Propulsion Laboratory. The prototype and four flight units were constructed at Space Technology Laboratories, Inc. and delivered to JPL. Because of a decision by NASA to concentrate on the primary mission objectives, the use of these instruments in the Ranger program has been indefinitely postponed.

The low-energy proton detector system which was described in the original grant request was proposed for the POGO spacecraft. We have been informed that this experiment cannot be included in the first POGO spacecraft. Accordingly, we have oriented our subsequent instrument development program toward other flight opportunities within the NASA program. The development work on the Ranger instrumentation has been extended to produce several other charged-particle instruments which incorporate many of the basic elements of the Ranger design. Two of these instruments have been described in proposals recently submitted to NASA for participation in the Pioneer flight program.

The principal scientific investigator under this grant, Thomas A. Farley, had previously been designated an experimenter in the Mariner B program in a joint particle experiment with Alan Rosen and Nathaniel Sanders. Because of spacecraft booster limitations, the spacecraft size and payload capability was sharply reduced. The mission objective was changed from Venus to Mars, and the program was redesignated Mariner C. A revised proposal for the new spacecraft was submitted by Farley, Rosen, and Sanders. Because of the reduction in payload capability, it appears that this experiment, which is very similar to the Ranger instrument, cannot be carried on the Mariner C vehicle.

Since the original grant award, Paul Coleman, one of the Mariner II magnetometer experimenters, has joined our group. A substantial effort in the analysis of data from the magnetometer aboard Mariner II has been undertaken. The earlier portion of this effort involved the detection and correction of errors introduced into the data by the data reduction program or by other steps in the process of identifying, tabulating, and plotting the telemetered data. More recently, the

work here has been the determination of corrections for the temperature variations of the magnetometer and of other pertinent subsystems. Other required corrections include, for example, the changes in the field at the magnetometer due to the variations in the position of the high-gain antenna and due to the changes in the solar panel currents. These corrections are being established from available data on the spacecraft performance and are being prepared so that computer techniques may be used to apply the corrections to the magnetometer data. This work is being performed by two graduate students and one undergraduate.

Shortly, computer programs will be developed to permit correlation studies and spectral analyses. Tests and calibrations of magnetometers being developed for the '64 Mariner flight should begin in the near future.

II. Instrumentation

The Ranger instruments, and those instruments which are the extension of the Ranger development program, utilize a scintillation counter as the detector, with two different scintillators mounted on it. This combination, known as a phoswich, permits separation of electrons and protons within certain energy ranges by an analysis of the pulse shapes at the output of the photomultiplier tube. The following electronic circuits have been devised for use with these sensors.

A. Slow (CaI scintillator) pulse detector.

The fluorescence decay time of a CaI scintillator is about 1.1 microsec. The fluorescence decay time of a plastic scintillator is short compared with 6 nanosec, which is the characteristic rise-time of the photomultiplier tube being used.

A slow pulse detector circuit is one which has an output if and only if a slow pulse is present (some energy loss in the CsI crystal). The circuit consists of a delay line and coincidence circuit. The block diagram and a typical performance curve are shown in Fig. 1. The circuit used in these measurements had a delay time (L) of $\frac{1}{2}$ microsec, and the threshold for a $\frac{1}{2}$ microsec pulse (T) was 60 mv. If the photomultiplier tube output is differentiated so that a plastic scintillator pulse is 100 nanosec or less in length, a CsI pulse will still be of the order of 1 microsec in length, because of the long fluorescence decay. This circuit will obviously discriminate very sharply against the plastic scintillator pulse.

B. Fast (plastic scintillator) pulse detector

The fast pulse detector is basically a double differentiating circuit followed by a high pass amplifier (see Fig. 2). Each section of the differentiator has a time constant of approximately 20 nanosecs. If the fluorescence decay were a pure exponential, the discrimination against CsI pulses would be approximately 300 to 1, as verified with a pulse generator. In actual use, however, high frequency components in the CsI pulse cause the discrimination ratio to be reduced to about 12 or 15 to 1. Experiments with color filters between the CsI crystal and photomultiplier cathode are being performed with the hope of improving this result.

C. Differential pulse height analyzer

The eight channel differential pulse height analyzer was a completed design at the time of our original proposal, and it has proved quite satisfactory as incorporated into the Ranger instruments.

D. Analog storage and readout systems

The analog storage system is also the same as that described in the original proposal. The readout method for the analog storage system has been changed to provide a longer storage time and to operate at the higher temperature specification of the Ranger vehicle. As originally proposed, the system was designed for not more than 10 sec storage at 120°F. The Ranger instrument required 40 sec storage at 130°F. In order to meet this specification, the diode readout gating and transistor output amplifier were replaced by a magnetic reed commutator and an electrometer tube output amplifier. These changes resulted in a leakage resistance of approximately 5×10^{10} ohms across the storage capacitor, which is adequately high to assure storage for several minutes over the required temperature range. The performance of the storage system, measured on a Ranger flight instrument, is shown in Fig. 3. A block diagram of the readout system is shown in Fig. 4.

The remaining circuits developed on this grant were conventional in design and implementation.

III. Educational Program

The participation of students in this experimental program is considered to be an essential part of our activities. Grant funds are presently being used to support two graduate students. Two other graduate students and one undergraduate are working with the data reduction and experimental programs, although they are not supported by grant funds. Three of these five students are looking forward to theses within the framework of our research program. We expect that

opportunities for thesis research will develop as we take a more active part in flight programs and the analysis of resulting data.

The investigators under this grant have taken an active part in University seminar and study groups, and have presented papers before scientific groups. Published scientific papers whose preparation was supported by this grant include:

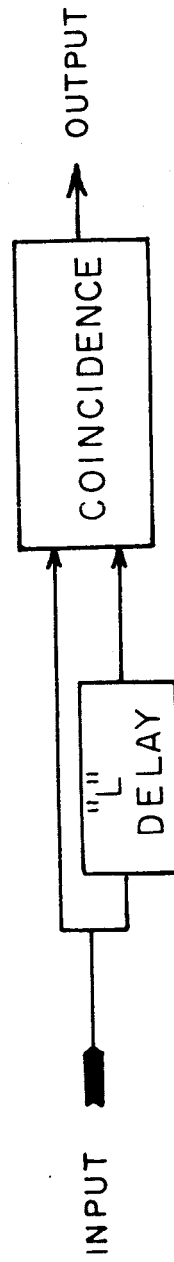
Coleman, P.J., Jr., L. Davis, Jr., E.J. Smith, and C.P. Sonett,
Interplanetary Magnetic Fields, Science, 138, p. 1099-1100, 1962.

Farley, T.A., The Growth of our Knowledge of the Earth's Outer
Radiation Belt, Rev. of Geophysics, in press.

IV. Directions of Future Research

The investigators under this grant intend to pursue further the development of instrumentation for space flight, direct participation in NASA flight programs, and the reduction and analysis of data. A proposal for continued support of these activities has already been submitted to NASA. Detailed descriptions of future activities were included in that proposal.

THRESHOLD, IN UNITS OF THE THRESHOLD AT PULSE LENGTH L



BLOCK DIAGRAM AND MEASURED PERFORMANCE SLOW PULSE DETECTOR

$L = 1/2$ MICROSECOND
 $T = .060$ VOLTS PEAK

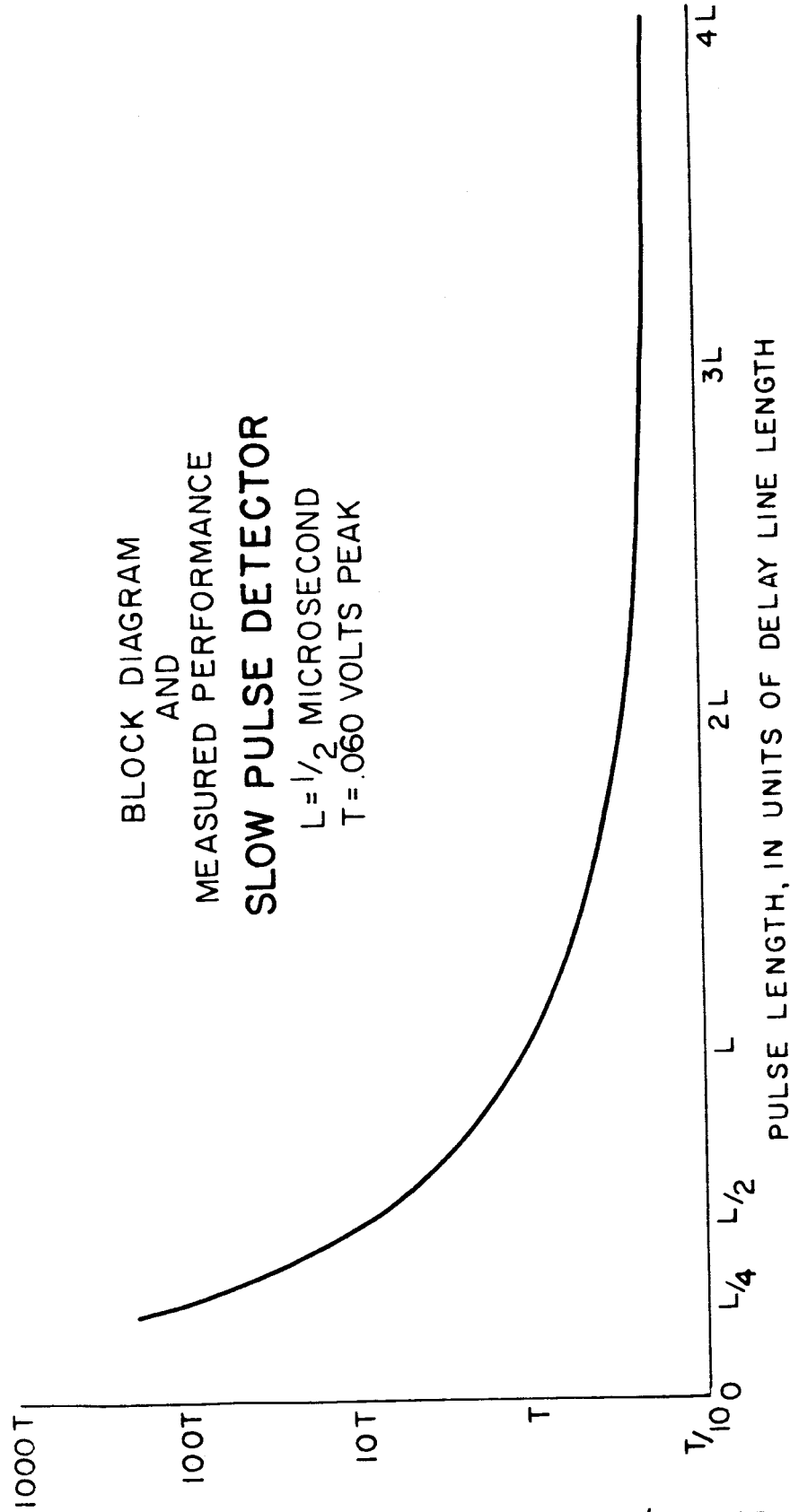


Figure 1

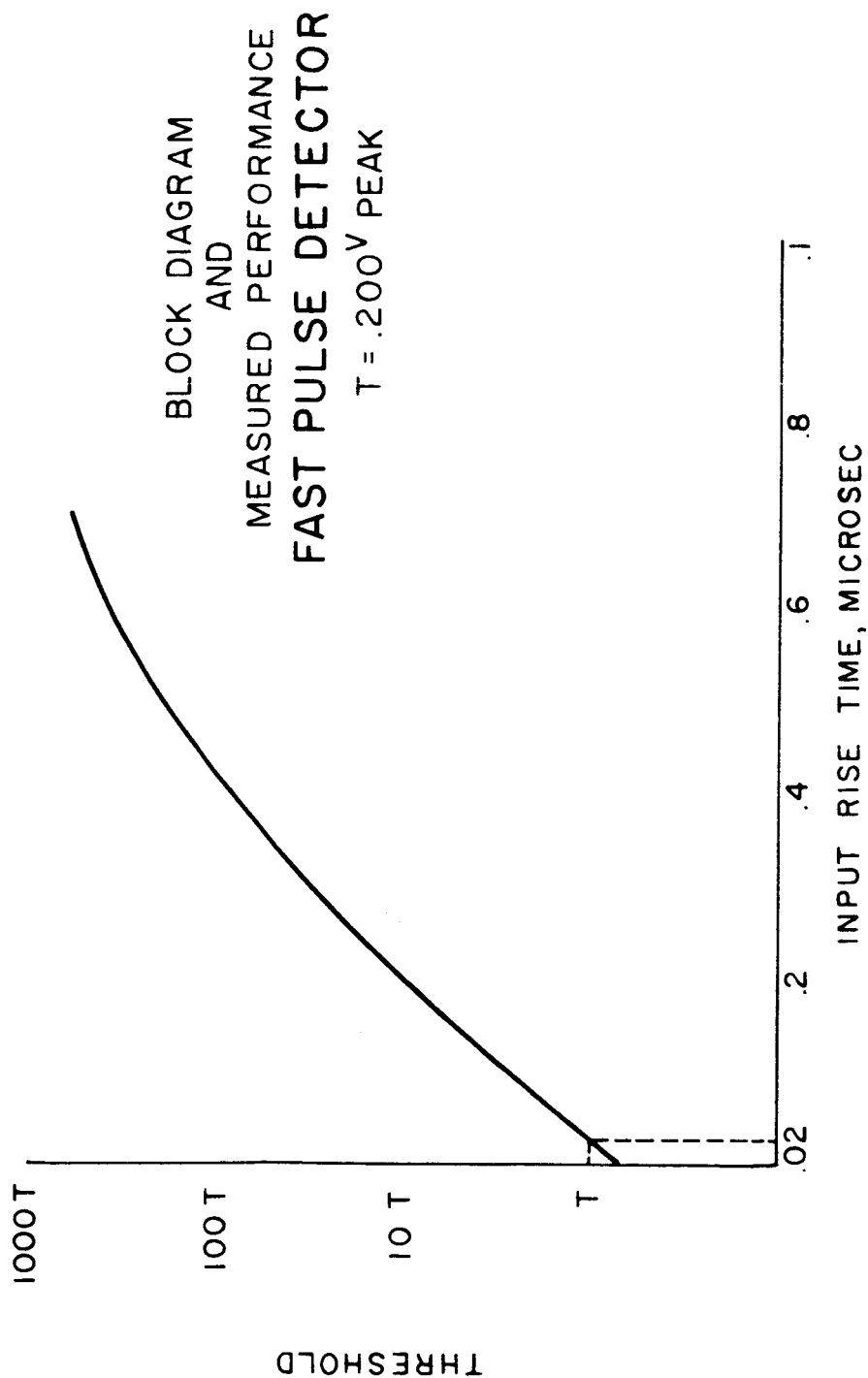
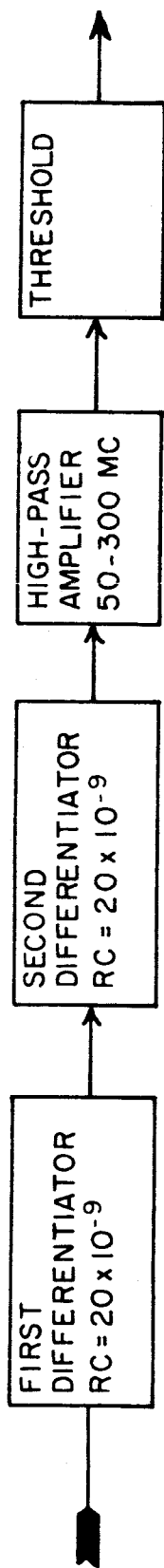


Figure 2

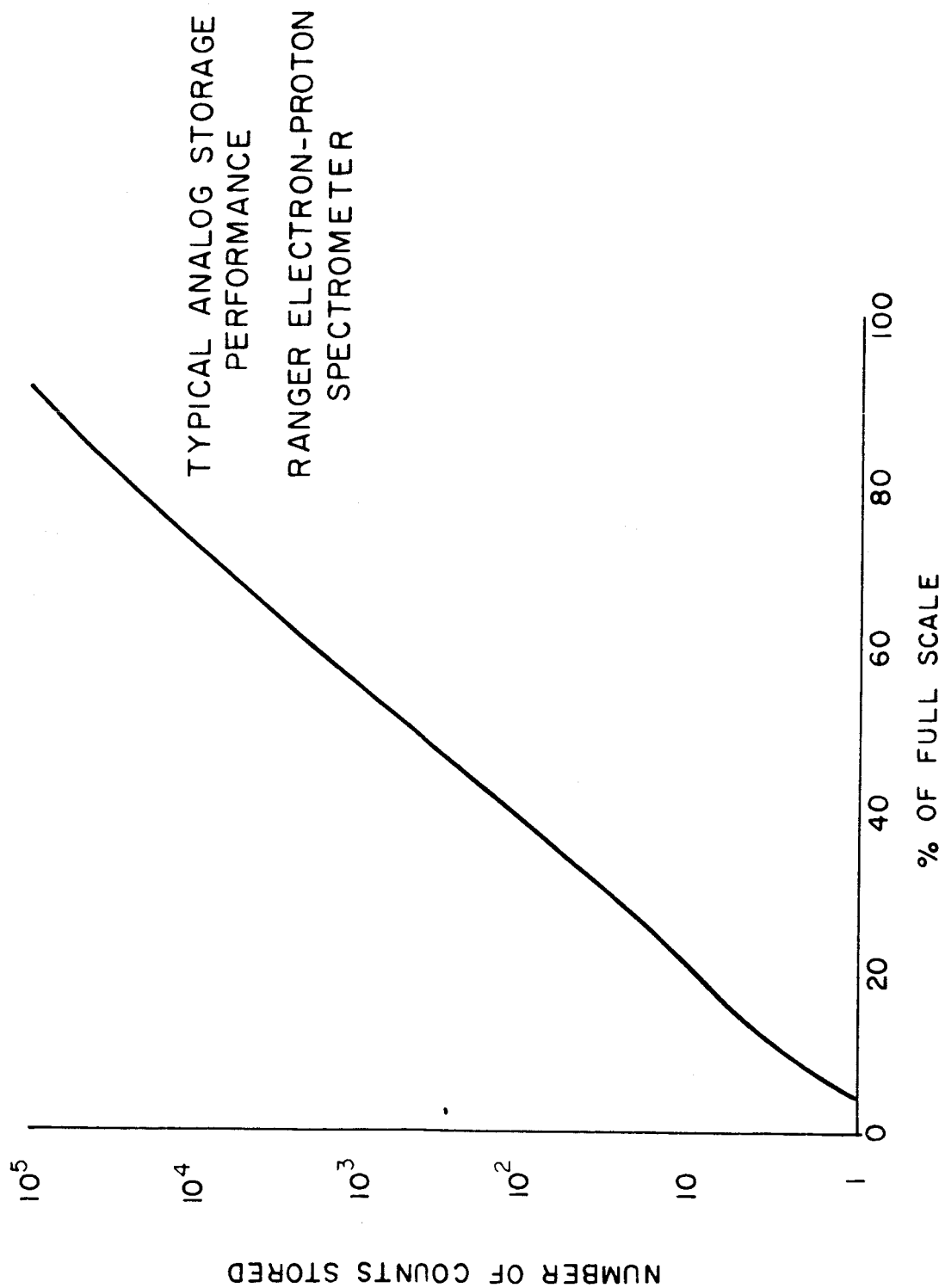
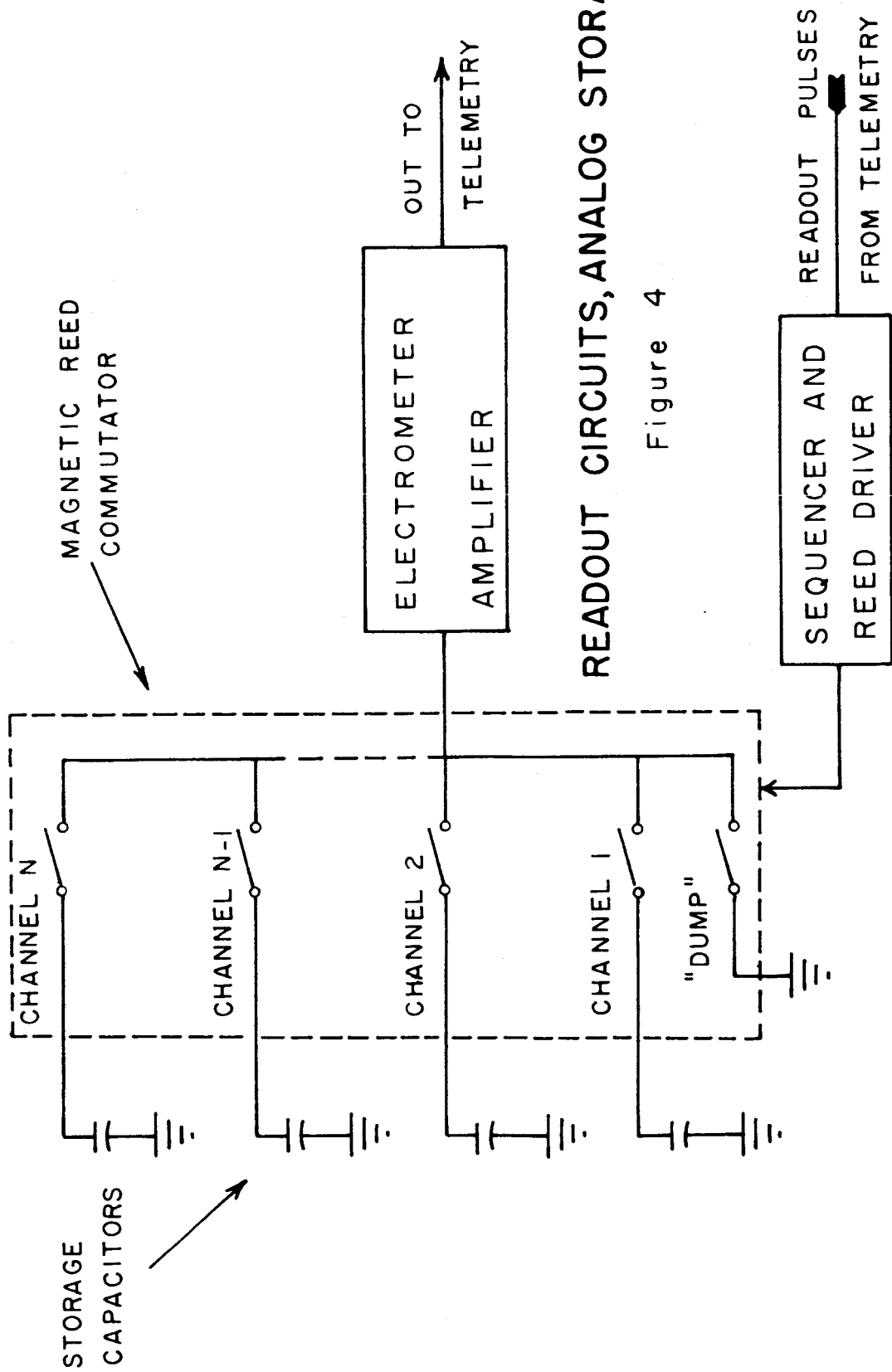


Figure 3



READOUT CIRCUITS, ANALOG STORAGE

Figure 4